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BRITISH MUSEUM (NATURAL HISTORY)

CANKER (NECTRIA) OF PARA RUBBER (HEVEA BRASILIENSIS).

History in Ceylon.

THE history of this disease in Ceylon is more encouraging than that of most parasitic diseases attacking economic plants. Not because there is anything in the disease itself, or its progress, that make it less to be feared than similar diseases in other plants, but because when the number of trees affected was comparatively inconsiderable, the disease was observed and steps taken to prevent its spreading and getting a firm hold of a large number of trees.

In November, 1903, my attention was called to the existence of a disease in two plantations on the north side of the Kalu-ganga, and on my visiting and investigating these places I found them to be seriously affected with a disease caused by the attacks of a parasitic fungus of the Nectria family. Fortunately, neither of the two places was of any size or containing a large number of trees, the total number of rubber trees on both places being about 12,000. At the same time I received specimens from an estate on the south side of the Kalu-ganga, and as it was important to at once form an estimate as to how far this disease was affecting the Para rubber in that district, I made an inspection of all the estates there, and after seeing all the rubber trees I estimated the percentage of trees attacked by the canker was only ½ per cent., *i.e.*, 1 in 200 trees. This estimate was reassuring, and

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showed that in these estates the attacks were of recent origin and that it had been observed in its early stages.

It was unfortunate that measures had not been taken earlier in the case of the two rubber plantations on the north side of the river to stamp out the disease.

These plantations belonged to Government, but had been leased year by year, with the natural consequence that proper attention had not been paid, either to keeping the places weeded or to giving that constant inspection and care of the rubber trees which is necessary to keep any cultivation free from parasitic and other diseases.

At the end of the current lease in March of this year the Government placed these plantations in my hands to be freed from the disease, and I at once started with what labour I could get to clear the place up and eradicate the canker. I am thus able to understand in laying down the details of curative measures the difficulties which must be overcome if the canker is allowed to invade trees and to continue for some time unchecked. From my observations of the rate of growth of the fungus in other trees I am of the opinion that in the case of the majority of trees at the Edengoda plantation the canker had been in the trees some four or five years. The Assistant Conservator of Forests informs me that he had noticed the disease for some two years before it was brought to my notice, but attributed it to various environmental causes.

The fact that so large a proportion of the trees as 30 per cent. in the small plantation at Edengoda were affected is interesting as showing the rate of progress of this disease if no measures are taken to check it. Comparing the rate at which the canker spreads on individual trees and from tree to tree with the ravages of the canker which attacks cacao (a different fungus, but closely allied), the latter seems to be more rapid. So many factors, however, must be considered before we can compare a diseased cacao estate with a rubber plantation similarly affected that it is not possible to make this statement very definitely.

It is to be hoped that in Ceylon it will not be possible to observe on any places the rate of progress of the disease unchecked as it has been easy to do in the case of cacao.

External effects of the Disease.

The external effects of the canker fungus in the stem or branches of the Para rubber are not so easily observed as in the case of cacao, but to a certain extent they are alike. Nectria in Europe is known best on the apple tree, and on this and other trees it causes open wounds which gave it its popular name of "canker." The Nectria on Para rubber, however, like its relation on cacao, does not cause any atrophy or open wound at the place where it is permeating the tissues of the plant. I have observed many cases of trees in which the fungus has been present for a long period and has invaded a large area, but in none of these has any thickening of the stem or branch taken place, and in none is there any reason to suppose that the fungus causes a wound or cracking of the bark. As is very general in cases of parasitic fungi on tropical timber trees, directly parts of the tree have been thoroughly permeated by the mycelium of the fungus and the chemical contents of these parts changed they are an attraction for various boring insects, and these very soon invade the cankered places and form wounds of various sizes. When this occurs the insects sometimes continue their tunnelling into the parts of the bark containing either very little of the fungus mycelium or where it has not penetrated. This causes a flow of latex, and at a cankered place where insects have in some quantity bored into the tree an exudation of latex will be observed and often a cracking of the bark.

It must, however, be remembered that this exudation of latex and cracking of the bark is not always met with in the case of canker, and must not be regarded as a sign whereby the presence of the evil may be detected. In the majority of trees, and in all cases where the fungus has not been living long in the bark, no such effects will be noticed.

Abrasions of the bark and exudations of latex should, as will afterwards be explained, be carefully looked out for and treated, but in many cases these will be found to be due to various accidental causes, and not to the ravages of the canker fungus.

The external colour of the bark in places where the canker fungus is present is in many cases different from that of the healthy parts, but no actual colour can be given as typical of a canker spot. As a rule it is a little darker in colour and the surface of the bark somewhat different. In my field note-book I recorded a very large number of descriptions of the external appearance of canker areas, but these notes vary greatly—"Darker brownish-green; rough," "much darker and less green than surrounding bark," "spot showed yellowish brown before cutting," and even "lighter than rest of the bark, but differently cracked on periderm." It thus is clear that no constant and definite external signs can be given whereby to detect the presence of the enemy.

Symptoms below the Bark.

The tissue under the outer bark, however, always shows by its colour when there is any considerable quantity of the canker fungus mycelium present. Instead of a bright clear yellow or red, as is found in the healthy bark of the Para rubber tree when cut, the colour of the cankered tissue recently attacked is of a dirtier yellow or even a neutral tint, and when the fungus has got complete hold the tissue is claret-coloured, and not unlike the colour of the inside of the fruit wall of a ripe mangosteen.

The Fungus and Latex.

An important fact to be observed is that in those areas invaded by the mycelium of canker fungus no latex will be found at all. Cut as you may, no latex will exude, except from the surrounding tissues, which are not yet permeated by the mycelium. A microscopical section of these areas shows the laticiferous vessels empty. I am at present

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Nectria Sp. on Hevea braziliensis

working at the pathology of this fungus and its relation to the latex, and have not yet solved the problem as to whether the mycelium of the fungus itself feeds on the latex, or whether the latex is used up by the cells of the host plant to repair the ravages of the fungus. I hope to be able to give time to this matter and with a larger number of microscopic sections in pieces of bark containing the fungus mycelium to elucidate this point.

Be that however as it may, the fact remains that wherever the fungus is present in the bark the contents of the tree used by the planter, *i.e.*, the latex, is absent, and for this reason alone its eradication is imperative, and when we know that the canker fungus will, if unchecked, kill the whole tree the necessity of an early discovery of the disease and its complete excision is still more emphasized.

Parts of the Tree affected.

The position of the diseased areas on the stem or branches varies almost indefinitely, and I have found it on almost all parts of the tree except the young branches and the roots. I have never found it on the latter, and all attempts to inoculate these with tissue from diseased places failed. I have found it more often on the lower parts of trees, but this is probably due to the fact that my observations have naturally been very much more on the parts of the tree within ten feet of the ground, though I have climbed many trees and frequently used a ladder. Even taking into consideration the fact that it is not so probably noticed on the higher parts of the tree, I yet think that on a careful examination of the whole of a large number of trees from top to base it will be found that the canker more often affects the lower portions of the stem and the lower branches.

In the rough diagram which I have made for this Circular, and which by the kindness of the Surveyor-General I was able to have reproduced, I have given two typical cases of trees affected by canker. In the figure A the tree has small patches of canker on the stem about two feet from the

ground, and the lowest branch is also affected, and the canker spreading into the stem from that branch. In figure B the whole of the tree above about three feet is cankered, and in this case the canker has originated somewhere high up the tree and is spreading downwards. If the tree be cut off just above the sucker *a* and so as to clear all the discoloured tissue, the sucker will live, and other suckers will probably be formed and the tree thus not entirely lost.

Life-history of the Fungus.

The internal effects of the fungus in the tissues of the plant are similar to those found in the case of any parasitic fungus in timber trees. A section under the microscope shows the mycelium or vegetative part of the fungus permeating all the interstices of the cells and penetrating the cell walls. Its action in regard to the laticiferous vessels I am not yet in a position to describe, but hope to find out this important point when I have investigated further.

In the parts of the cambium where the fungus is found in less quantity and where the discolouration is very slight it is not easy to detect the mycelium, and many of my sections, though carefully searched, seemed to contain no strands of mycelium. I think it probable, however, that the mycelium escaped my notice, and not that there is discolouration where no fungus mycelium is acting on the tissues.

When the fungus has been growing in the tree for some time—my observations have not been carried on long enough to give an estimate of the length of time—it produces its spores. Spores may for practical purposes be considered as the seeds of the fungus. They are the reproductive bodies, and by means of these the fungus spreads from tree to tree. Wind is probably the chief distributing agent, but rain washing down a tree carries the spores from a cankered spot higher up to places lower down the tree, and no doubt the ubiquitous ant and other insects carry the spores about with them after travelling over a spore-laden area, and so convey them to a new and unaffected area.

The spores are of two kinds; the first spores produced, which are called "gonidiospores," are of a whitish-gray colour in mass, and look somewhat like thick white mould. Later on and produced at the same places, pushing their way out from behind the gonidiospores, are the perfect fruits of the fungus or perithecia which are characteristic of the group Nectria, to which this fungus belongs. They are when seen with the naked eye like grains of red pepper, sometimes a mass of them occupying a space as big as a 10-cent piece or even bigger. When looked at through a lens they will be seen to be in shape not unlike minute strawberries, some ten to fifteen making a mass about equal in size to a pin's head; they are roundish with a point when fully formed. In the rough diagram which I have made for this Circular the drawing C in the right-hand corner represents a piece taken out of the bark of a tree on which are seen the perithecia or fruits of the Nectria on rubber. If these are cut open and examined with the microscope they will be found to contain a large number of transparent sacs or asci (figure D), and each of these sacs contains eight ascospores, one of which is again figured at E still further enlarged. The size of these spores may perhaps be imagined if it is stated that it would take more than 5,000,000 to cover a 10-cent piece one layer thick. Each of the perithecia or small red fruits contains many hundreds of asci, and each ascus contains eight spores. It will thus be realized what potentialities for spreading the disease exist in each small red fruit. Burning is the only certain way of preventing these spores from growing.

The germination of these spores, as I have observed it in water cultures in the laboratory, is of perhaps more scientific than practical interest for this paper, but speaking generally, it is similar to that of most fungus spores. A single or sometimes two tubes or promycelia are pushed from the spore—somewhat as the rootlet is pushed out from a seed—and this, upon finding itself in a suitable medium, *i.e.*, the bark tissues of Hevea braziliensis, will grow on and branch and rebranch until it makes a matted mass of mycelium through the cells

of the bark and produces the discoloured patch which we recognize as a canker spot.

I have not had sufficient time at my disposal to carry out, as I should have liked to have done, an exhaustive series of inoculation experiments. To gain an exact and definite knowledge of the life-history of a parasitic fungus and its pathological effect on its hosts the best method is to place the spore of the fungus on the bark of the tree under conditions which will allow it to grow and enter the tissues of the tree. The life-history of the fungus can then be watched, its rate of growth estimated, and the general effect on the tree carefully observed. The inoculations I made at Peradeniya were too few, and they did not succeed, and I was unfortunate in having to make them at a dry time of year, when the chance of successful infection is lessened. Had I been able to devote myself exclusively to the investigation of Nectria on Hevea brasiliensis my work might have been more complete.

Trees curing themselves.

I have observed cases that point to a cankered spot being naturally healed over by the tree. The conditions under which this natural cure takes place are probably as follows:—

The attack of the fungus is followed by a dry period, and the sun playing directly on the diseased area the fungus mycelium is not able to spread into the surrounding tissues very rapidly, and the neighbouring tissues are stimulated to produce a callus or cushion of new cells which grow quickly enough to push out the diseased part. This seems the only explanation of the cases I have observed and of which I have preserved specimens. It is pathologically a most interesting point, but one in which it is not easy after the whole process is finished to form an opinion as to the exact causes which have brought it about. I mention it in order not to omit any of my observations taken during my investigations of this disease, but it should not be considered by the practical planter as being of any importance or as helping him to any appreciable extent in his stamping out

the canker. It will be better for the planter to remember what happens in the great majority of cases of rubber trees infected by the canker fungus, viz., that once infected the cankered area goes on increasing, and unless steps are taken to prevent its spread it will eventually kill or maim the tree.

Withering back of Trees and partial failure of Fruit Crops.

When carrying on my investigation of the canker in stem and branch of the rubber tree I also made observations as to an abnormal falling of leaves and withering of branches which in the end of 1903 and the beginning of this year was generally prevalent among rubber trees. No fungus was present in these withering branches, and there were no signs of any insect attack. There had been an abnormal absence of sun and continuance of rainy and damp weather. I came to the conclusion that this lack of health on the part of many of the trees was due to climatic and environmental causes, and not to any specific disease. This diagnosis was supported by the trees a little later, when the weather was more favourable, producing new leaf on the branches which had withered back and resuming their former healthy appearance. In addition to this withering due to lack of sunshine the first crop was to a great extent damaged. A large proportion of the fruit set in 1903 did not ripen and split in the normal way, but remained on the tree and blackened or fell off without splitting and ejecting the seeds. I examined a very large number of such fruits from tapped and untapped trees. Though it was suggested that "going off" of the fruit was associated with heavy tapping, observations did not support this at all. I found on counting the number of blackened unopened fruits from untapped trees that they were in equal proportion to those from tapped trees of similar age. The microscopic examination of the fruits showed no trace of fungus or insect attack on the fruit wall or in the unripened seed. I examined about 3,000 fruits, but without finding any

ground for supposing that the disease was specific, *i.e.*, due to the attack of a specific fungus or insect. I was thus led to the conclusion that this blackening and "going off" of the fruit was due, like the withering of the branches, to environmental and climatic causes, lack of sunlight having prevented the tree from ripening all its fruits.

Canker Fungus on Fruit.

The same loss of a considerable proportion of fruit occurred this year, and I again examined a large number of fallen unopened fruits. On some of these I found the red perithecia or fruits of the Nectria fungus, and on carefully examining a large number of fruits found a proportion of about 10 per cent. to contain these fruits. It is of course probable that the Nectria fungus was present in a large proportion of the fruits, though the fungus had not produced its tell-tale red perithecia.

Having kept in my laboratory the 3,000 fruits of 1903 crop which I had previously examined, I again carefully looked at these and found on four of them the red perithecia of the Nectria fungus.

The structure of these Nectria fruits is exactly similar to those produced on the stems of the tree, and the spores from the perithecia found on the rubber fruits when germinated in a drop culture behaved exactly as the spores from perithecia found on the bark of the tree.

In order to satisfy myself as to the fact that this Nectria on the fruit walls of dead fruits fallen off the tree was the same fungus as that which causes canker in the stems and branches, I took some of the spores and inoculated twelve healthy trees with them. The inoculations were made in the usual way. A small cut was made through the bark of the tree and the spores were inserted in an emulsion by means of a paint brush. Four of these trees became diseased at the point of inoculation, and the tissue was discoloured as in the canker found in the stem. As I was unable to further watch these trees I excised all the discoloured parts, but this

evidence is, I think, fairly conclusive that it is the same Nectria on the fruit as on the tree.

This habit of the fungus to affect the fruit as well as the stems and branches of the tree makes it more dangerous. As we know by experience of a similar fungus on the cacao, it is by means of its living on the cacao pods that the cacao canker fungus chiefly spreads. It grows more quickly in the softer tissue of the fruit, and when the fruits drop off and are carried about the spores are easily spread. It is thus imperative that these black fruits should be collected as often as possible and on no account be allowed to remain longer than it is impossible to avoid on the ground.

I am doubtful as to whether the fungus attacks the fruits when on the tree and is therefore parasitic on the fruits, or only when they fall to the ground. An examination of some fifty or more fruits blackened and remaining on the trees showed no sign of fungus mycelium. I am thus led to the belief that this fungus may be both saprophytic and parasitic, *i.e.*, capable of growing both on dead material and on living parts of the rubber tree. If I had been able to continue my investigations, no doubt this important point could be solved by seeing whether dead fruits free from fungi could be infected with the fungus.

The Nectria fungus as a rule produces its gonidiospores or first form of spores on the living parts of the tree when it has been permeated by the mycelium of the fungus, but not absolutely killed. The perithecia or perfect fruits are generally only found on the dead parts of the tree, and are only produced when the fungus has so thoroughly permeated the part of the tree it has attacked as to kill that part.

Whether the Nectria on Hevea brasiliensis is both parasitic and saprophytic is not absolutely proved, but the preponderance of evidence seems to me to point to its being what is termed a "facultative parasite," that is, a fungus which usually grows on dead vegetable matter, but which under favourable conditions can live in the living tissues of plants or animals.

Prevention and Cure.

In the Circulars of this Department dealing with diseases of cultivated plants the most important part from a practical point of view must naturally be that which deals with methods of prevention and cure.

With canker in rubber, as with all other diseases, whether in animals or plants, curative measures when taken in the earlier stages of the disease are far easier, less costly, and have much more certainty of success.

The first thing of importance, therefore, in discussing means of eradicating this disease is that it should be observed and treated in its early stages. As I have pointed out, it is not always easy or possible to detect the cankered spot by any external appearance. The Tamil cooly has proved in the case of cacao disease that he possesses a very quick eye for the detection of a slight clue on the outside of the tree to show disease within, and I have frequently observed with great interest that the cooly on canker work in cacao can almost, it would appear, by intuition detect the place on the stem or branch of a cacao tree where the knife was needed, often when I had failed to see anything suspicious.

The planter will therefore probably find that when he has found a cooly who is good at this inspection and curative work it will be well even if a little increase of pay is needed to retain him for this work alone.

When the place in the bark of the tree has been found to be discoloured a sharp knife is necessary to do the excision work cleanly and well. A pruning knife is an excellent weapon, but if the wound is large I have found a draw knife to do the work quicker, and Mr. MacAdam has found very effective a home-made draw knife made from thickish hoop iron about 1½ inch broad. This last tool has the advantage of being bendable, and therefore easily worked round the curves of a tree stem. It has not been patented.

All the discoloured tissue must be entirely removed down to the wood. It will sometimes be found that the affected

tissue does not go down to the wood, in which case, after shaving down quite clean of any discolouration, the rest of the cambium can be left. A margin of not less than two inches should be cut round the discoloured area, so as to excise not only the absolutely diseased part, but the environs, where some of the mycelium may be stretching out into the healthy tissue. If such strands of mycelium be left under suitable conditions of damp air they will continue to live and the place will remain cankered. Places which have been cut out must not be considered as certainly cured, but must some months after be again examined at the edges to see if the canker has been thoroughly removed, and if any discolouration is still found, cut out again.

In dealing with the higher parts of the tree more difficulties will be found. In the first place it is not always possible to detect spots of disease high up in the stem or branches of the tree. Where any branch is seen to be withering back while the rest of the tree is in full leaf this should be cut off at some distance, a foot or more below the point at which it is dead. It is not possible always to be sure in such cases that canker has caused the death of the branch, but it is wise in all cases of dead branches to have them cut off at once. All parts of the stem or branches which are cut out or off should be burnt as near as possible to the place where cut. To carry disease-laden and often spore-laden wood through the estate is courting danger. At the Edengoda and Yatipowa plantations I found in the majority of cases that when a tree was badly attacked high up it was almost impossible to have the excision thoroughly carried out, and as the trees had been planted at least twice too thickly I cut the trees down and destroyed the diseased parts.

In searching for canker in stems of trees all at all suspicious places should be scraped with the back of the knife, and if the normal yellowish-green colour is not found further scraping should be done. The more this slight scraping is done the better it will show the Superintendent that the trees have been examined, and as far as my observation goes it

seems in the majority of cases that this scraping acts as a stimulus and increases rather than diminishes the amount of latex obtained afterwards from the tree.

It is not necessary to cut into the tree to be sure that no fungus is present; if the outer bark—periderm—is scraped the colour below will give at once indication of health or disease.

The only effective methods of dealing with fungi parasitic in the tissues of stem and branch are those of surgery. Complete excision of the diseased tissue is the quickest, finest, and cheapest way of getting rid of the evil. The rubber tree is exceptionally active in healing over wounds, and when the mycelium of the fungus is entirely removed the tree will complete the cure for itself.

Applications of washes or sprays have various disadvantages which the method of excision with the knife has not. It is not possible to get a substance which will as quickly and as thoroughly destroy the affected tissue. It is unwise to leave dead tissue on the tree even if it has been covered with a fungicide. It is very difficult in the case of a wash or other application for the Superintendent to examine the work done and to see whether it has been efficiently carried out, also whether the cure has been effected. The surgical method enables the place to be easily examined, and it can be seen whether the fungus-infected tissue has been entirely removed or not.

Conditions favourable to Disease.

The conditions favourable to the spread of the fungus are damp and heat. In Ceylon there is always enough of the latter to help the fungus, but if rubber is planted not too thickly and if the ground is well drained the amount of moisture in the air and on the stems of the trees during a large part of the year, perhaps the majority of days, is too little to enable the spores to germinate.

As a rule the canker is more likely to be found in low-lying damp fields and not so much on open ridges, but I

have seen it even in the driest places. It is a common mistake to confuse the conditions favourable to the growth of the disease with the cause of the disease, *i.e.*, the fungus. No amount of dampness will, if no spores of parasitic fungus be present, cause a cankered spot, but when the spore of a canker fungus alights on the bark of a tree when the air is charged with moisture or when the bark is dripping wet, then it will grow and produce a cankered spot, and once in the tissues of the tree the dryness of the air outside will not kill it. In the same way close planting will not induce the disease, but when the disease has once found a footing in a closely-planted plantation the proximity of the trees gives the fungus a better chance of spreading; this is both because of the comparative density of the shade and the short distance that spores have to travel to secure other victims.

A periodical inspection of rubber trees is essential in order to find and treat the disease in its earliest stages. Whether this should be done once or more than once in the year is perhaps a matter more for the planter himself to decide, but it would certainly be erring on the safe side to have an inspection every six months. The time of year for this inspection should be chosen when there is dry weather. During wet weather it is much harder to detect the presence of the canker, and the good effects of the excision are much diminished by the presence of rain or atmosphere charged with moisture. The leafless period is a good time for examination and for the work of cure.

Spraying.

The question of spraying the trees with a fungicide is worth serious consideration. Spraying is often misunderstood; it is not a *curative* but only a *preventive* measure. It consists in covering the surface of plants with a substance containing copper salts or sulphur, and when these substances are on the surface any spore alighting and beginning to germinate is at once killed. If rubber trees are

thus coated with a solution of copper sulphate—and 1 part in 4,000 is sufficient to have a fungicidal effect—they are while the copper sulphate is on the surface immune from fresh attacks of canker fungus. The question of cost generally determines the practical value of spraying. In the case of cacao canker it has been proved by the experiments of Mr. Herbert Wright, Controller of the Experiment Station, Peradeniya, that the cost of spraying is more than repaid by the increased health of fruit and trees. Should the disease any further increase, an annual spraying of copper sulphate, which should be done at a cost of not more than Rs. 2 per acre, would no doubt be found to be repaid in decrease of new cankered trees.

A spray that would carry not less than twenty-five or thirty feet would be needed, and such a machine can be obtained either in the Knapsack form or in the compressed air sprayers used both in Ceylon and other countries.

Having made an inspection of a large part of the rubber of Ceylon and searched the trees carefully for disease I am of opinion, which I think would be shared by those having a knowledge of diseases of timber and fruit trees, that Para rubber in Ceylon is growing vigorously and healthily and is exceptionally free from diseases of any sort. The time has now gone by when surprise is expressed at a disease being found on a cultivated plant, and it is understood that the surprise should be felt if any plant was found which suffered from no insect or fungal enemies. The unavoidable danger of growing the same species of tree in large numbers and close together is a point that it is of importance to constantly emphasize. In mixed forests the spread of a specific disease affecting one species is much hampered, and conversely in aggregations of the same species much helped. All the more reason, therefore, for a constant care and supervision, that all diseases may be discovered in their earliest stages and measures taken to prevent their spread.

The exceptionally large profits which rubber is giving, and I am confident will continue to give, make it impossible for

the excuse to be given that the money needed for care and treatment is not forthcoming. It is to be hoped that the Para rubber industry in Ceylon will be insured against loss by disease in the most practical and economic way, *i.e.*, by spending money to prevent disease while it is at a minimum. Let the motto be "Hevea sana in plantario sano." Ceylon has valuable property in the Para rubber estates. Let the owners be careful to insure against disease, just as the owner of valuable houses or pictures insures against loss by fire by having an efficient and constantly alert fire brigade service.

The proportion of trees affected is at present very small, and it should not be allowed to increase. If measures are strenuously carried out I see no reason why the present ½ per cent. should not be reduced to an even smaller proportion of trees. I would suggest that at stated periods a general tour of the rubber districts should be taken by the Government Mycologist and an estimate made of the number of trees affected. This will give a definite knowledge as to how the war is being waged and with what success, and if more stringent measures are found advisable they can then be adopted.

I regret that this account of the canker of Para rubber is not exhaustive as I had hoped it would be, and still leaves some points of interest not settled. I was not able to devote my whole time to the investigation of the canker fungus, and was only able to pay short visits to rubber places and to observe the disease for a few days at a time. Other diseases of cultivated plants claimed such of my time as could be given to these important matters. The absence of the Director of the Royal Botanic Gardens on special service in the Malay States still further reduced my time available for research work at this disease. My going on leave preparatory to giving up my appointment in Ceylon necessitates my writing this record of the investigation up to the present date. I hope that the future history of this disease will be chiefly the description of the success of curative and remedial measures, and that my successor may find the

number of specimens of Hevea brasiliensis on which he can study the pathological effects of Nectria very few.

Summary.

To sum up, Para rubber, like other trees, is not exempt from disease. It is attacked by a canker fungus of the family Nectria, which lives in the tissues of the stems and branches. This fungus discolours the bark tissues where it is present, and there is a total absence of latex wherever it has got a hold of the bark. The fungus has also been found in the blackened fruits which have dropped from trees and not ripened and split in the ordinary way. If the fungus is allowed to remain in the tree it will kill the tree and produce spores by which it may infect other neighbouring trees.

The fungus can be eradicated by surgical means. When cut out thoroughly with the knife the tree quickly covers over the wound.

Regular inspections should be made and all cankered areas on stem or branch cut out *and burnt.* All fruits lying on the ground should be collected *and burnt.*

The sun is the greatest helper in eradicating the disease, and the work should be done as far as possible in sunny weather and when the trees are leafless and consequently are exposed to sunshine.

If regular search is made for the canker and the diseased parts are cut out and with the fallen fruits burnt as soon as possible, there is no reason to suppose that the amount of disease will not be reduced to an even smaller proportion than at present, and probably entirely suppressed.

I would like in closing this account of my work in connection with the rubber canker to express my indebtedness to many rubber planters for valuable help cordially given. The rubber planter, perhaps because he is a more modern creation, deals with his cultivation rather more in an experimental scientific manner than his brother planter in tea or cacao. He is not trammelled by any traditions as to methods of cultivation, and has to get his knowledge first

hand. This necessitates a greater amount of observation of the trees in his care both as regards their freedom from disease and their production of latex. The practical and efficient treatment of the canker fungus may therefore, I think, be left in his hands with the assurance that he will not allow it to get the better of him while any efforts on his part can ensure its eradication.

The Chairman of the Kalutara Planters' Association, Mr. R. W. Harrison, and his colleague, Mr. C. O. MacAdam, have given me great assistance and allowed me to inoculate various trees with a view to gaining knowledge of the early stages of disease and the rate of progress of the fungus in the tree. I wish to especially thank these gentlemen for their kindness and hospitality.

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November 22, 1904.